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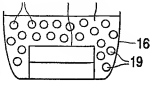
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: WHITE LIGHT EMITTING LIGHTING SYSTEM



(57) Abstract: A white light emitting lighting system, comprising a blue or UV light emitting diode and a coating comprising a yellow luminescent phosphor having a peak emission wavelength greater than 550 nm, wherein the phosphor comprises a $S_{(2-x-y-z)}Ca_yBa_zSiO_4:Eu_x$ phosphor, and wherein $0<x<=0.06$ and $0<(3y+2z)<=0.5$. If the diode is a UV light emitting diode the coating further comprises a blue luminescent phosphor.

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White light emitting lighting system

The invention relates to a white light emitting lighting system, comprising a blue or UV light emitting diode and a coating comprising a yellow luminescent phosphor.

Conventional LED lighting systems for producing white light typically comprise either LEDs or phosphor-LEDs. Lighting systems which use LEDs produce white light by combining various combinations of red, green, and blue LEDs. Phosphor-LED based lighting systems produce white light by using one or more various luminescent phosphor materials on top of a blue or UV light LED to convert a portion of the emitted blue or UV light into light of a longer wavelength. If a blue light LED is used, the phosphor should emit yellow light to obtain white light. If a UV light LED is used, an additional phosphor should be applied which converts part of the UV light into blue light, for instance a $BaMgAl_{10}O_{17}$:Eu phosphor.

An advantage of using a UV light LED with blue and yellow luminescent phosphor as opposed to a blue light LED with yellow luminescent phosphor is, that the first is less vulnarable to colour variations caused by variations in the quantity of phosphor present in the LED.

In general it is easier to produce white light with phosphor-LED based lighting systems as compared with LED based lighting systems because phosphor-LEDs do not require mixing and have lower material costs (they are inherently mixed).

It is known to use a blue LED with the yellow emitting phosphor being a cerium doped yttrium aluminum garnet $Y_3Al_5O_{12}$:Ce, also referred to as YAG:Ce.

The object of the invention is to provide an alternative yellow emitting phosphor to be used with blue or UV LEDs in order to obtain a white light LED, and which may have better colour or efficiency properties.

Thereto the invention provides a blue or UV light emitting diode and a coating comprising a yellow luminescent $Sr_{2-x-y-z}Ca_yBa_zSiO_4:Eu_x$ phosphor, and wherein $0<x<=0.06$

and $0<(3y+z)<=0.5$. Peferably $0<x<=0.04$, $0<=y<=0.1$ and/or $0<z<=0.3$. More preferably $0.01<=x<=0.03$, $0.01<=y<=0.06$ and/or $0.03<=z<=0.25$. Tests have shown that a strontium silicate phosphor containing small amounts of Ca, Ba and Eu emit at a peak emission wavelength greater than 550 nm (yellow), which makes such phosphor suitable for the desired purpose.

According to the present invention the amount of Sr is predominant, resulting in a peak emission wavelength of greater than 550 nm (yellow), which makes it possible to mix it with blue light, and to obtain a white light composed of two color components only.

The advantages, nature, and various additional features of the invention will appear more fully upon consideration of the illustrative embodiments now to be described in detail in connection with accompanying drawing wherein:

Fig. 1 is a sectional view of a typical phosphor-LED used in the lighting system of the invention.

Fig. 2 is a graph showing the peak emission wavelengths of phosphor examples.

It should be understood that the drawing is for purposes of illustrating the concepts of the invention and is not to scale.

According to Fig. 1 the lighting system of the invention generally comprises a phosphor-LED 14 consisting of a blue or UV LED and at least one phosphor which emits at certain light spectral wavelength (colour), to produce white light. The LED 14 is conventionally constructed using standard AlInGaN or AlInGaP processing and comprises a LED chip 15 mounted in a reflective metal dish or reflector 16 filled with a transparent epoxy 18. The epoxy 18 filling the reflector 16 contains grains 19 of one or more types of luminescent phosphor materials mixed homogeneously therein. The phosphor grains 19 convert a portion of the light emitted by the LED chip 15 to light of a different spectral wavelength.

Fig. 2 shows the peak emission wavelengths of five tested examples of phosphor materials of the type $Sr_{2-x-y-z}Ca_yBa_zSiO_4:Eu_x$. According to the invention examples C, D and E can be used in combination with a blue light emitting diode, or alternatively with a UV light emitting diode and a blue luminescent phosphor, to produce white light.

While the foregoing invention has been described with reference to the above examples, various modifications and changes can be made without departing from the spirit of the invention. Accordingly, all such modifications and changes are considered to be within the scope of the appended claims.

CLAIMS:

1. A white light emitting lighting system, comprising a blue or UV light emitting diode and a coating comprising a yellow luminescent phosphor having a peak emission wavelength greater than 550 nm, wherein the phosphor comprises a $Sr_{2-x-y-z}Ca_yBa_zSiO_4:Eu_x$ phosphor, and wherein $0<x<=0.06$ and $0<(3y+z)<=0.5$.

2. The system according to claim 1, wherein $0<x<=0.04$, preferably $0.01<=x<=0.03$.

3. The system according to claim 1 or 2, wherein $0<y<=0.1$, preferably $0.01<=y<=0.06$.

4. The system according to claim 1, 2 or 3, wherein $0<=z<=0.3$, preferably $0.03<=z<=0.25$.

5. The system according to any of the previous claims 1-4, wherein the phosphor further comprises a cerium doped yttrium aluminium garnet (YAG:Ce) phosphor.

6. The system according to any of the previous claims 1-5, wherein the diode is a UV light emitting diode, and the coating further comprises a blue luminescent phosphor.

7. The system according to claim 6, wherein the blue luminescent phosphor comprises a $BaMgAl_{10}O_{17}:Eu$ phosphor.

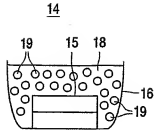
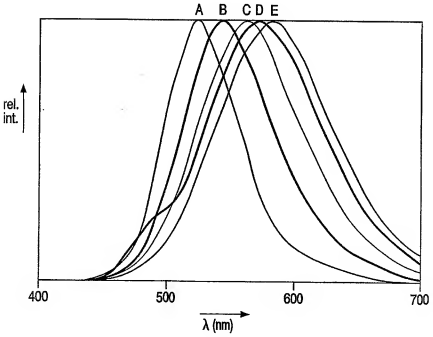


FIG. 1



A $Sr_{.98}BaSiO_4:Eu_{.02}$
B $Sr_{1.42}Ba_{.55}SiO_4:Eu_{.02}$
C $Sr_{1.73}Ba_{.25}SiO_4:Eu_{.02}$
D $Sr_{1.96}Ca_{.02}SiO_4:Eu_{.02}$
E $Sr_{1.92}Ca_{.06}SiO_4:Eu_{.02}$

FIG. 2

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01L33/00 C09K11/59

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C09K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 544 160 A (THE GENERAL ELECTRIC COMPANY LIMITED; ALFRED HAMILTON MCKEAG; PETER WH) 31 March 1942 (1942-03-31) page 3, column 2, line 73 - line 87; claims 1-5; tables I,II	1-7
A	US 2003/085853 A1 (SHIIKI MASATOSHI ET AL) 8 May 2003 (2003-05-08) claims; tables 1,2	1-7
A	DE 18 01 486 A1 (N.V.PHILIPS' GLOEILAMPENFABRIEKEN) 29 May 1969 (1969-05-29) claims 1-5	1-7

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Lehnert, A

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 2003, no. 03, 5 May 2003 (2003-05-05) & JP 2002 332481 A (SUMITOMO CHEM CO LTD), 22 November 2002 (2002-11-22) abstract	1-7

INTERNATIONAL SEARCH REPORT

IB2004/051582

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
GB 544160	A	31-03-1942	NONE		
US 2003085853	A1	08-05-2003	JP	2003132803 A	09-05-2003
			JP	2003142005 A	16-05-2003
			JP	2003142004 A	16-05-2003
			CN	1417831 A	14-05-2003
DE 1801486	A1	29-05-1969	NL	6714518 A	29-04-1969
			AT	279736 B	10-03-1970
			BE	722851 A	24-04-1969
			FR	1603626 A	10-05-1971
			GB	1205319 A	16-09-1970
			JP	48037715 B	13-11-1973
			SE	332675 B	15-02-1971
JP 2002332481	A	22-11-2002	CN	1345908 A	24-04-2002
			EP	1193306 A2	03-04-2002
			US	2002038861 A1	04-04-2002